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03 Strategies for Enhancement in Food Production (Animal Husbandry)

1. Introduction :

- **Animal husbandry** is the agricultural practice of breeding and raising livestock. As such it is a vital skill for farmers and is as much science as it is art.
- Animal husbandry deals with the care and breeding of livestock like buffaloes, cows, pigs, horses, cattle, sheep, camels, goats, etc., that are useful to humans. Extended, it includes poultry farming and fisheries.
- Fisheries include rearing, catching, selling, etc., of fish, molluscs (shell-fish) and crustaceans (prawns, crabs, etc.).
- Since time immemorial, animals like bees, silk-worm, prawns, crabs, fishes, birds, pigs, cattle, sheep and camels have been used by humans for products like milk, eggs, meat, wool, silk, honey, etc.
- It is estimated that **more then 70 per cent of the world livestock population is in India and China.** However, it is surprising to note that the contribution to the world farm produce is only **25 per cent,** i.e., the productivity per unit is very low.
- Hence, in addition to conventional practices of animal breeding and care, newer technologies also have to be applied to achieve improvement in quality and productivity.

2. Dairy Farm Management :

- Dairying is the management of animals for milk and its products for human consumption.
- In dairy farm management, we deal with processes and systems that increase yield and improve quality of milk.
- Milk yield is primarily dependent on the quality of breeds in the farm. Selection of good breeds having high yielding potential (under the climatic conditions of the area), combined with resistance to diseases is very important.
- For the yield potential to be realised the cattle have to be well looked after – they have to be housed well, should have adequate water and be maintained disease free.
- The feeding of cattle should be carried out in a scientific manner – with special emphasis on the quality and quantity of fodder.
- Besides, stringent cleanliness and hygiene (both of the cattle and the handlers) are of paramount importance while milking, storage and transport of the milk and its products.
- Nowadays, of course, much of these processes have become mechanised, which reduces chance of direct contact of the produce with the handler.
- Ensuring these stringent measures would of course, require regular inspections, with proper record keeping. It would also help to identify and rectify the problems as early as possible.
- Regular visits by a veterinary doctor would be mandatory.

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(1) Livestock :

Domesticated animals, especially the farm animals, kept for profit are collectively called as **livestock**.
e.g. Cattle, Buffaloes, Sheep, Goat, Pigs, Horses, Camel etc.

(2) Breed :

A group of animals related by descent and similar in most characters like general appearance, features, size, configuration, etc., are said to belong to a breed.

(A) Breeds of Cattle/Cow (*Bos indicus*) :

Depending upon the utility, the cattle are classified into the following groups -

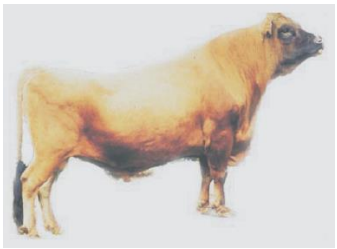
(i) **Milch breeds** (Milk producing animal)
(ii) **Draught breeds** (Used for working)
(iii) **General utility breeds** (Can be used for both purpose)

Indian breeds of Cattle :

	Milch Breeds	Distribution
1.	Gir	Rajasthan, Gujarat
2.	Sahiwal (Best in India)	Punjab, Haryana, U.P.
3.	Red Sindhi	Andhra Pradesh
4.	Deoni	Andhra Pradesh
5.	Rathi	Rajasthan

	Draught Breeds	Distribution
1.	Malvi	Raj., M.P.
2.	Nageri	Haryana, Delhi, U.P.

Exotic breeds of cattle :
Holstein-Friesian (Best milch breed in world),
Jersey, Guernsey, Ayrshire,
Brown swiss, Red Dane.


Jersey

(B) Breeds of Buffaloes (*Bubalus bubalis*) :

Surti, Niliravi, Nagpuri (Ellichpuri), Jaffrabadi, Bhadawari, Mehsana, **Murrah (Haryana).**

(C) Breeds of Sheep (*Ovis aries*) :

Dorset, Horn and **Merino** are exotic breeds of sheep use for good quality of wool, mutton and also use for cross breeding.

Indian Breeds of Sheep :

	Breed	Distribution	Use
1.	Patanwadi	Gujarat	**Wool for army hosiery**
2.	Lohi	Punjab, Rajasthan	Milk, good quality wool.
3.	Rampur-Bushair	UP, HP, Rajasthan, Punjab, Haryana	Superior Cloth, Brown Colour fleece
4.	Nali	Haryana, Punjab, Rajasthan	Superior carpet wool

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(D) Breeds of Goat (*Capra capra*) :

The fine soft wool called **PASHMINA** is the underfur of Kashmiri & Tibetan goat.

	Breed	Distribution
1.	Kashmiri Pashmina	Hills of Kashmir, Tibet, HP
2.	Gaddi	Himachal Pradesh
3.	Jamunapari	UP, MP

(E) Breeds of Pig (*Sus sacrofa*) :

- Pig's meat is called PORK.
- The care & management of pigs is called PIGGERY.

Indigenous pigs		Distribution
1.	Ghunghroo	Bengal
Exotic Pigs		
1.	Berkshire	U.K.
2.	Large white Yorkshire	U.K.

(F) Mules & Hinny :

- Male Horse × Female Donkey = Hinny (Sterile)
- Female Horse × Male Donkey = Mule (Sterile)
- Stallions are uncastrated male horse especially used for breeding purpose.

Mule

3. Animal Breeding :

- Breeding of animals is an important aspect of animal husbandry. Animal breeding aims at increasing the yield of animals and improving the desirable qualities of the produce.
- For what kind of characters would we breed animals? Would the selection of characters differ with the choice of animals?
- When breeding is between animals of the same breed it is called **inbreeding**, while crosses between different breeds are called **outbreeding**.

(1) In-breeding :

- Inbreeding refers to the mating of more closely related individuals within the **same breed for 4-6 generations.**
- The breeding strategy is as follows – superior males and superior females of the same breed are identified and mated in pairs.
- The progeny obtained from such matings are evaluated and superior males and females among them are identified for further mating.
- A superior female, in the case of cattle, is the cow or buffalo that produces more milk per lactation. On the other hand, a superior male is the bull, which gives rise to superior progeny as compared to those of other males.
- Try to recollect the homozygous purelines developed by Mendel. A similar strategy is used for developing purelines in cattle as was used in case of peas.

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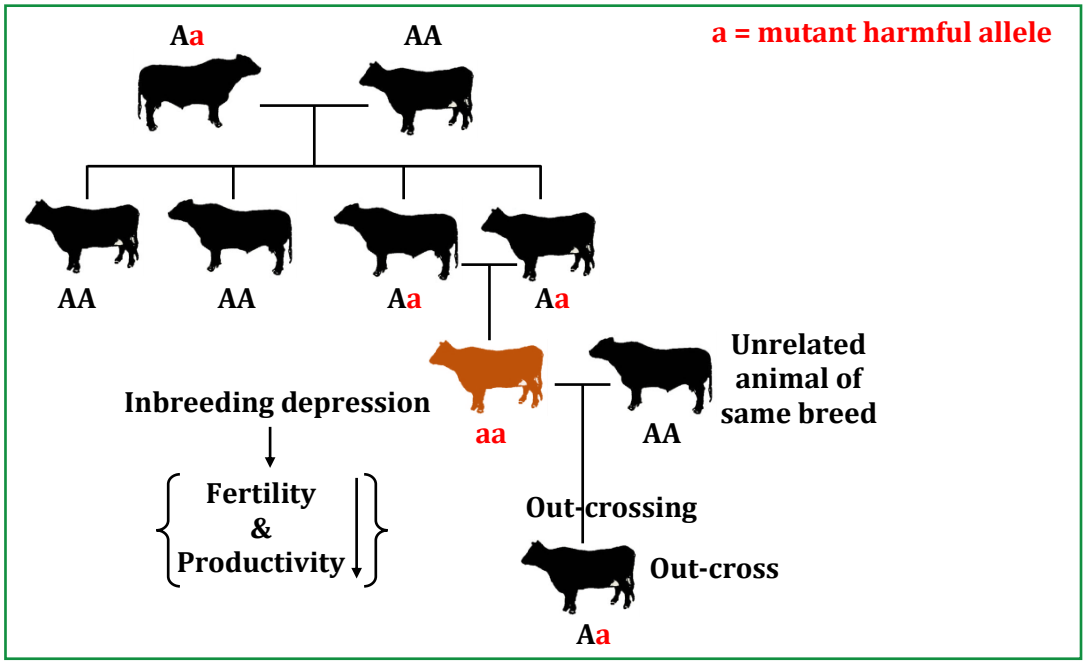
- Inbreeding **increases homozygosity.** Thus inbreeding is necessary if we want to **evolve a pureline** in any animal.
- Inbreeding **exposes harmful recessive genes** that are eliminated by selection.
- It also helps in **accumulation of superior genes** and **elimination of less desirable genes.**
- Therefore, this approach, where there is selection at each step, increases the productivity of inbreed population. However, **continued inbreeding,** especially **close inbreeding, usually reduces fertility and even productivity.** This is called **inbreeding depression.**
- Whenever this becomes a problem, selected animals of the breeding population should be mated with unrelated superior animals of the same breed. This usually helps restore fertility and yield.



(2) Out-breeding :

- Out-breeding is the breeding of the unrelated animals, which may be between individuals of the same breed (but having no common ancestors), or between different breeds (cross-breeding) or different species (inter-specific hybridisation).

(A) Out-crossing :

This is the practice of mating of animals within the **same breed,** but having **no common ancestors on either side of their pedigree upto 4-6 generations.** The offspring of such a mating is known as an out-cross. It is the best breeding method for animals that are below average in productivity in milk production, growth rate in beef cattle, etc. A single outcross often helps to overcome inbreeding depression.

(B) Cross-breeding :

In this method, superior males of one breed are mated with superior females of another breed. Cross-breeding allows the desirable qualities of two different breeds to be combined. The progeny hybrid animals may themselves be used for commercial production. Alternatively, they may be subjected to some form of inbreeding and selection to develop new stable breeds that may be superior to the existing breeds. Many new animal breeds have been developed by this approach. **Hisardale is a new breed of sheep developed in Punjab by crossing Bikaneri ewes and Merino rams.**

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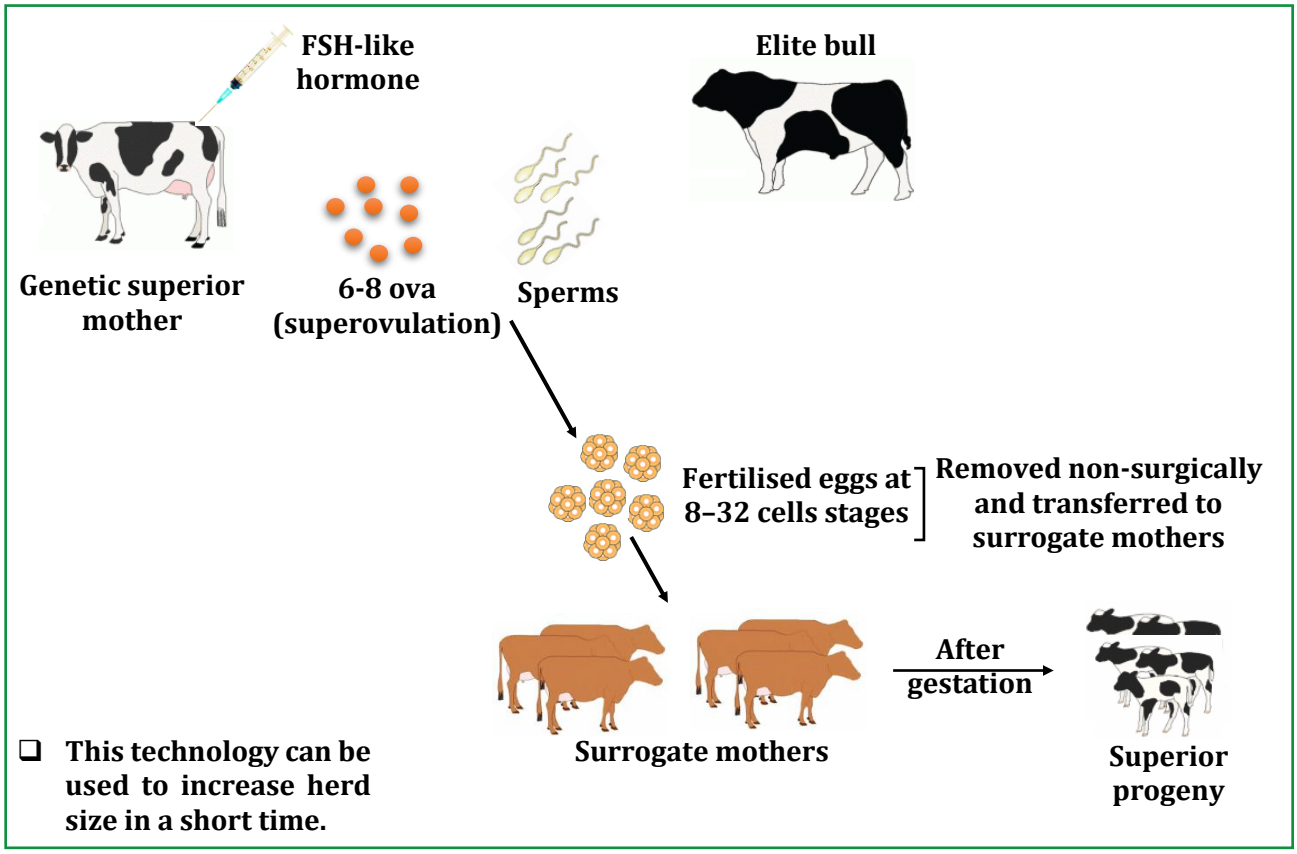
(C) Interspecific hybridisation :

In this method, **male and female animals of two different species are mated.** In some cases, the progeny may combine desirable features of both the parents, and may be of considerable economic value, e.g., Mules are sturdier and hardier than their parental species, that are well suited for hard work in difficult terrains like mountainous regions.

- **Controlled breeding experiments** are carried out using **artificial insemination.**
- The semen is collected from the male that is choosen as a parent and injected into the reproductive tract of the selected female by the breeder.
- The semen may be used immediately or can be frozen and used at a later date. It can also be transported in a frozen form to where the female is housed. In this way desirable matings are carried.
- **Artificial insemination helps us overcome several problems of normal matings.** Can you discuss and list some of them?

  Often, the success rate of crossing mature male and female animals is fairly low even though artificial insemination is carried out.
- To improve chances of successful production of hybrids, other means are also used.
- **Multiple Ovulation Embryo Transfer Technology (MOET)** is one such programme for herd improvement. In this method, a cow is administered hormones, with **FSH-like** activity, to induce follicular maturation and super ovulation instead of one egg, which they normally yield per cycle, they produce **6-8 eggs.**
- The animal is either mated with an elite bull or artificially inseminated. The fertilised eggs at **8–32 cells stages,** are recovered **non surgically** and transferred to **surrogate mothers.**
- The genetic mother is available for another round of super ovulation.


FSH-like hormone
Elite bull
Genetic superior mother
6-8 ova (superovulation)
Sperms
Fertilised eggs at 8–32 cells stages
Removed non-surgically and transferred to surrogate mothers
After gestation
Surrogate mothers
Superior progeny
❑ This technology can be used to increase herd size in a short time.

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- This technology has been demonstrated for cattle, sheep, rabbits, buffaloes, mares, etc. High milk yielding breeds of females and high quality (lean meat with less lipid) meat-yielding bulls have been breed successfully to increase herd size in a short time.

4. Poultry :

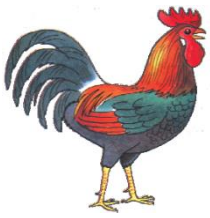
- Poultry is the class of domesticated fowl (birds) used for food or for their eggs. They typically include **chicken** and **ducks**, and sometimes **turkey** and **geese**. Turkey is recently domesticated bird. The word poultry is often used to refer to the meat of only these birds, but in a more general sense it may refer to the meat of other birds too.
- Selection of disease free and suitable breeds, proper and safe farm conditions, proper feed and water, and hygiene and health care are important components of poultry farm management.

Note :
- Poultry and poultry products are a rich source of animal protein & right kind of fats for good health.
- In our country poultry mainly means domestication of chickens for meat & eggs.

(1) Breeds of Hen (*Gallus gallus*) :

Indigenous (Desi) or Indian breeds	Exotic Breeds
Aseel, Ghagus, Karaknath, Brahma, Bursa, Black Bengal, Chittagong, Tellicherry etc.	**White leghorn,** Rhode island red, Plymoth rock, New Hampshire, Sussex, Australop, Minorca etc.

- Aseel is best game bird, it is used in **cock fighting**.
- Poultry birds exclusively **grown for meat** are called **broilers** (plymoth rocks).
- Poultry birds exclusively **grown for eggs** are called **layers** (white leghorn).
- Indian breeds are slow growing, less efficient converters and produce fewer eggs (60 eggs/years).
- The broilers with high nutritive value have been produced by cross breeding **(heterosis)**



Leghorn

(2) Common Diseases of Poultry :

(A) Viral Diseases of Poultry : Fowlpox, Bird flu (H_5N_1–Virus), Ranikhet (New castle diseases) infectious bronchitis, lymphoid leukosis and are common viral diseases of poultry.

(B) Bacterial Diseases : Fowl cholera, Pullorum, Corryza, Mycoplasmosis and Spirochaetosis.

(C) Fungal Diseases : Aflatoxicosis *(Aspergillus flavus)*, Brooder pneumonia, Aspergillosis and thrush.

Note : If any of the infectious disease has affected a mass proportion of the chicken and hens, then the best and safer decision, to avoid the fatal consequence, is to destroy the affected individuals. A poultry keeper must be aware about the common diseases so as to ensure the well being of hens and also of man.

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5. Apiculture / Bee-keeping :

- Bee-keeping or **apiculture** is the maintenance of hives of honeybees for the production of honey. It has been an age-old cottage industry.
- Bees are the **pollinators** of many of our crop species such as **sunflower, Brassica, apple** and **pear.** Keeping beehives in crop fields during flowering period increases pollination efficiency and improves the yield–beneficial both from the point of view of crop yield and honey yield.
- Although bees are very active throughout the year but in winter they become sluggish and are very active in spring.

(1) Important Species of Honey-Bees :

(A) ***Apis dorsata*** **(Rock bee)-** It is also named as saarang bee. It is of largest size and yields highest amount of honey. However, It is of highly aggressive nature and migratory species, which is not suitable for rearing by man.

(B) ***Apis indica*** **(Indian Mona bee)-** It lives across the whole country and is most common bee. It is mild in nature, so that it is easily manageable during rearing. Mona bee yields about 3-4 kg. of honey per hive.

(C) ***Apis florea*** **(Bhringa bee)-** This bee is smallest in size and of timid nature. It yields only about 250gms of honey per hive. Hence it is not suitable for commercial purpose.

(D) ***Apis mellifera*** **(European bee)-** This bee is of mild nature. It yields 9-10 times more honey than mona bee. It is the most useful bee for commercial purpose. The **Italian variety** of this species is by far the most important variety.

(2) Modern Method of Apiculture :

- Modern method of apiculture makes use of artificial bee hive. They are more convenient as these may be reused and can be shifted easily to safer place in adverse weather conditions. In addition to above, these are easy to handle and can be carried in a simple and easy manner.

(3) Procurement and Rearing of Honey-Bees :

- The increased demand of honey has led to large-scale beekeeping practices; it has become an established income generating industry, whether practiced on a small or on a large scale.
- Bee-keeping can be practiced in any area where there are sufficient bee pastures of some wild shrubs, fruit orchards and cultivated crops.
- There are several species of honeybees which can be reared. Of these, the **most common species** is ***Apis indica***.
- Beehives can be kept in one's courtyard, on the verandah of the house or even on the roof. Bee-keeping is not labour-intensive.
- Bee-keeping though relatively easy does require some specialised knowledge and there are several organisations that teach bee-keeping. The following points are important for successful bee-keeping:
  - Knowledge of the nature and habits of bees,
  - Selection of suitable location for keeping the beehives,
  - Catching and hiving of **swarms** (group of bees),
  - Management of beehives during different seasons and
  - Handling and collection of honey and of beeswax.

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(4) Honey :

- Honey is a food of high nutritive value and also finds use in the indigenous systems of medicine. **It is the secondary product of apiculture.**
- It is an aromatic viscid, sweet material consists of 17% water, sugar protein, minerals vitamins etc. pH = slightly acidic
- Its specific gravity is 1.45 to 1.48
- Composition of honey-

i.	**Fructose**	–	**40-45%**	ii.	**Glucose**	–	**32-37%**
iii.	Water	–	17-20%	iv.	Sucrose	–	1-2%
v.	Enzymes & pigments	–	2.21%	vi.	Minerals	–	1%
vii.	Vitamins	–	B_1, B_6, C & D				

(5) Bee Wax :

- Honeybee also produces beeswax, which finds many uses in industry, such as in the preparation of cosmetics and polishes of various kinds.
- **Wax is the real and primary product of apiculture.**
- It is obtained from bee hives
- This is a secretion of abdominal glands (wax glands) of worker bees.

(6) Propolis :

- It is prepared from a plant substance (pollen) called 'PROPOLIS'
- The propolis gives the wax a hardly nature
- Propolis is a gum like substance which is used by bees to repair the old & destructed parts of hive.

BEGINNER'S BOX-1 ANIMAL BREEDING, POULTRY, APICULTURE

1. Super ovulation and embryo transplantation are meant for improving:
(1) Human race (2) Live stock (3) Poultry (4) Plants

2. Jaffrabadi, Murrah and Mehsana are breeds of:
(1) Cow (2) Buffalo (3) Goat (4) Sheep

3. Best milch breed of cattle is:
(1) Red Sindhi (2) Deoni (3) Sahiwal (4) Holstein-Friesian

4. The contribution of India and China in the world farm production is:
(1) 10% (2) 70% (3) 50% (4) 25%

5. Which is an exotic breed of cattle?
(1) Jersey (2) Rathi (3) Sahiwal (4) Gir

6. Identify the Indian breed of sheep:
(1) Patanwadi (2) Dorset (3) Horn (4) Merino

7. What is the result of mating between male horse and female donkey?
(1) Donkey (2) Horse (3) Hinny (4) Mule

8. Which is a fungal disease in poultry?
(1) Fowlpox (2) Bird flu (3) Thrush (4) Ranikhet

10. Caring and management of beehives for the production of honey is called as:
(1) Apiculture (2) Poultry (3) Piggery (4) Sericulture

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6. Fisheries :

- Fishery is an industry devoted to the catching, processing or selling of fish, shellfish or other aquatic animals.
- A large number of our population is dependent on fish, fish products and other aquatic animals such as prawn, crab, lobster, edible oyster, etc., for food.
- Some of the freshwater fishes which are very common include ***Catla***, ***Rohu*** **and common carp.** Some of the marine fishes that are eaten include ***Hilsa*****, Sardines, Mackerel and Pomfrets.**
- **Pisciculture** is rearing catching & management of fishes.
- **Culture fishery** is the raising of fishes in tanks & ponds.
- **Capture fishery** is management of catching of fish without actually raising them.
- **Aquaculture** is rearing and management of useful aquatic plants and animals like fishes, oyster, prawns mussel etc.

Note : Blue Revolution is an effort to increase fish yield in India.

- Fisheries has an important place in Indian economy.
- For efficient utilization of different type of food in the pond as well as to reduces competition among fishes, it is necessary to cultivate 2 or 3 types of fishes together. This is called **composite or mixed farming.**

(1) Cultivable Species of Fresh Water Fishes :

Indigenous species-

(i) ***Catla catla*** (Catla)
(ii) ***Labeo rohita*** (Rohu) – Most common carp
(iii) ***Labeo calbasu*** (Calbasu)
(iv) ***Cirrhinus mrigala*** (Mrigal)
(v) ***Clarius batrachus*** (Magur)

(2) Exotic Species :

(i) ***Cyprinus carpio*** (Common carp)
(ii) ***Ctenopharyngodon idella*** (grass carp)
(iii) ***Hypopthalmicthys molitrix*** (chinese carp/silver carp)

(3) Marine Fishes - Are Generally Rich in Omega-3-Fatty Acids :

(i) ***Hilsa*** (Hilsa)
(ii) ***Salmo*** (Salmon)
(iii) **Sardinella** (Sardine)
(iv) **Harpodon** (Bombay duck)
(v) **Stomaleous** (Pomfret) - Introduced in Indian sea by foreigners
(vi) ***Rastrelliger*** (Mackerel)

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(4) Important Steps of Fish Culture :

- The major steps followed in the fish culture practice are briefly described in following lines-
- To obtain pure seed of the desirable fish species, healthy males and females of a superior fish species are selected. These are then induced to breed artificially by **(Hypophysation)** giving in them the injections of pituitary extract (containing FSH or LH) or a synthetic hormone like human chorionic gonadotropins (hCG). This stimulates females for spawning (egg production) and the males to emit milt (containing sperms) on the ova to fertilize them.
- Certain premier institutes in India viz., **Central Inland Capture Fisheries Research Institute (CICFRI), Barrackpore (W.B.); Central Marine Fisheries Research institute (CMFRI), Kochi (Kerala); Central Institute of Fresh water Aquaculture (CIFA), Bhubaneshwar (Orissa)** and many other institutes, are continuously engaged in the research and extension studies in the field of fisheries to make it more beneficial.

(5) By-Product of Fishing Industry :

- Isinglass is a high grade collagen produced from air bladder or swim bladder of certain fishes like cat fishes & carps. The isinglass prepared in Russia is of best quality.
- Isinglass is used to clarify wine.
- Shark Liver oil and Cod liver oil are very good source of vitamin A and D.
- Liver oil contains vit A, D, E & C.
- **DHA** (Docosa hexanoic acid) is also obtained from fish flour used as a supplement in baby food. (Certain algae are also source of DHA) essential for brain functioning.
- Skin of some fishes like shark (Shagreen) & rays are used for covering card cases, jewel boxes.
- Skin of some fishes like cod & salmon are used for the formation of leather.

Common diseases in carps –

- Fungal diseases – Gill rot
- Bacterial diseases – Fin rot, Tail rot, Dropsy etc.

7. Lac Culture :

- Lac is resinous secretion of last segment of *Laccifer lacca /Tachardia lacca* or Lac insect.
- The **insect is parasite** lives and breeds on the following host plants.

i.	Kusum	ii.	Babul
iii.	Ber	iv.	Palas
v.	Peepal	vi.	Mango
vii.	Sal	viii.	Fig

- The lac is a secretory product of **lac glands (Dermal glands).**

Note :

- India produces **75%** of the total world production.
- **In India the largest lac producing state is Jharkhand,** followed by MP, West Bengal & Maharashtra.

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8. Main Infectious Diseases of Domestic Animals :

Disease (s)	Pathogens	Symptoms
A. Bacterial diseases		
1. Anthrax	*Bacillus anthracis*	Blood mixed frothy secretion from external openings of body, increased respiratory rate.
2. Hemorrhagic septicaemia	*Pasteurella multocida*	High fever, pneumonia, respiratory distress, laming (pain during walking), septicemia.
3. Black quarter	*Clostridium chauvoei*	Fever, swelling in neck.
4. Brucellosis	*Brucella abortus*	Placental swelling, abortion, reduced fertility.
5. Bovine tuberculosis	*Mycobacterium bovis*	Tubercle nodes in lungs and lymph nodes respiratory distress.
6. Botulism	*Clostridium botulinum*	Paralysis of jaw, neck, leg, muscles, increased salivation, respiratory blockage.
7. Tetanus	*Clostridium tetani*	Stiffness in jaw and legs, opisthotonus. (excesive strain in neck region)
B. Viral diseases		
1. Rinderpest	Paramyxo virus	High fever, stomatitis, severe diarrhoea
2. Foot and Mouth Disease **(FMD)**	Picorna virus	Fever, Lesions in mouth, hoof, mammary glands and teats.
3. Cowpox	Orthropox virus	Rashes on mammary glands and teats, low fever, reduced appetite.
4. Rabies	Rhabdo virus	Changed behaviour, high excitability, madness, paralysis.
C. Protozoa born diseases		
1. **Babesiosis**	*Babesia* species	Jaundice, urine red and frothy, high fever haemoglobinuria.
2. Trypanosomiasis	*Trypanosoma evansi*	High fever, anaemia, animal lean and
3. Theileriosis	*Theileria* species	anaemia. Swelling in lymph nodes, high fever,
D. Helminth born diseases		
1. Ascariasis	*Neoascaris vitulorum*	Liver damage and fibrosis, swelling in lungs, intestinal obstruction.
2. Fasciolasis	*Fasciola* species	Bleeding from liver, anaemia, fibrosis of bile duct.
3. Trichuriasis	*Trichuris* species	Severe diarrhoea, decreased appetite, *anaemia*
E. Fungal diseases		
1. Ringworm	*Trichophyton* species	Alopecia, patches on skin, pus in infected area.
2. Aspergillosis	*Aspergillus* species	Lesions in lungs, respiratory system disorders, abortion.
3. Aflatoxicosis	*Aspergillus flavus*	Decreased appetite, liver damage, bloody diarrhoea, anaemia.

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Golden Key Points

- **Huskies** are thick fur coated dogs and used by Eskimos to draw their sledges.
- **Angoora wool** is obtained from Angoora rabbit.
- **Shahtoosh** is obtained from **Chiru (*Panthelops hodgsonii*)** (Tibetan antelope) it, is an endangered species due to high poaching. (It is finest and lightest wool).
- **India** ranks first in milk output in world.
- Cattle meat is also known as **Beef**.
- **Stilbestrol**
  – Synthetic estrogen.
  – used in the treatment of female animals for infertility.
  – Also induced lactation in sterile female.
  – But it is a carcinogen.
- **NDRI (National Dairy Research Institute)** was estabilised during first five year plan at Karnal (Haryana).
- Silk is secreted by larva but silk is obtained from cocoon or pupa.
- Juvenile hormone maintains the larval stage in silk worm.
- Natural silk is protein but artificial silk is usually carbohydrate.
- Mulberry (*Morus alba*) specially grown for silkworm is called **moriculture**.
- Marine animals are richer in Iodine
- Gambusia fish is used in biological control of mosquitoes.
- **River Dolphin** (mammal) is National aquatic animal of India.

BEGINNER'S BOX-2 — FISHERIES

1. Which is a fresh water fish?
(1) Rohu (2) Sardines (3) Mackerel (4) Pomfret

2. Hypophysation technique is used in:
(1) Pisciculture (2) Sericulture (3) Apiculture (4) Lac culture

3. Which is fungal disease in fishes?
(1) Fin rot (2) Gill rot (3) Tail rot (4) Dropsy

4. Central Inland Capture Fisheries Research Institute is situated in:
(1) Kerala (2) Orrisa (3) Maharashtra (4) West Bengal

5. The lac is secretion of:
(1) Salivary gland (2) Dermal gland (3) Tear gland (4) Wax gland

6. The lac is mainly composed of:
(1) Dye (2) Wax (3) Sugar (4) Resin

7. The foot and mouth disease in domestic animals causes due to:
(1) Virus (2) Bacteria (3) Fungus (4) Protozoa

8. Cattle meat is also known as:
(1) Mutton (2) Buff (3) Pork (4) Beef

9. Rearing of silkworm for commercial silk production is known as:
(1) Apiculture (2) Pisciculture (3) Sericulture (4) Aqauculture

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BEGINNER'S BOX — ANSWERS KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	2	2	4	4	1	1	3	3	4	1

BEGINNER'S BOX-2	Que.	1	2	3	4	5	6	7	8	9	
	Ans.	1	1	2	4	2	4	1	4	3	

ESSENCE

- More than 70% of the world livestock population is in India and China but their contribution to the world farm produce is only 25%.

Animal breeding :

It aims at increasing the yield of animals and improving the desirable qualities of produce.

Animal Breeding

Inbreeding

Mating of more closely related individuals within the same breed for 4-6 generations.

Out-breeding

Mating of the unrelated animals

3-Types
i. Out-crossing
ii. Cross-breeding
iii. Interspecific hybridization

Artificial insemination :

Semen collected from male (chosen as parent) is injected into reproductive tract of selected female.

MOET (Multiple ovulation embryo transfer technology) :

This method is used to increase herd size in short time.

Bee keeping :

Wax is primary product whereas honey is secondary product.

Fisheries :

It is an industry devoted to catching, processing or selling of fish, shellfish or other aquatic animals.

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04 Strategies for Enhancement in Food Production (Plant Breeding)

1. Introduction :

- India is mainly an agricultural country. Agriculture accounts for approximately 33 per cent of India's GDP and employs nearly 62 per cent of the population. After India's independence, one of the main challenges facing the country was that of producing enough food for the increasing population. As only limited land is fit for cultivation, India has to strive to increase yields per unit area from existing farm land.
- Traditional farming can only yield a limited biomass, as food for humans and animals. Better management practices and increase in acreage can increase yield, but only to a limited extent. Plant breeding as a technology has helped increase yields to a very large extent.
- The development of several high yielding varieties of wheat and rice in the mid-1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the Green Revolution.

2. What is Plant Breeding :

- Plant breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.
- Conventional plant breeding has been practiced for thousands of years, since the beginning of human civilisation; recorded evidence of plant breeding dates back to 9,000-11,000 years ago.
- Many present-day crops are the result of domestication in ancient times. Today, all our major food crops are derived from **domesticated varieties**.
- Classical plant breeding involves **crossing** or **hybridisation** of pure lines, followed by artificial selection to produce plants with desirable traits of higher yield, nutrition and resistance to diseases. With advancements in genetics, molecular biology and tissue culture, plant breeding is now increasingly being carried out by using **molecular genetic tools**.

The traits or characters that the breeders have tried to incorporate into crop plants are :-

- **Increased crop yield** and **improved quality**.
- Increased tolerance to environmental stresses (salinity, extreme temperatures, drought).
- Resistance to pathogens (viruses, fungi and bacteria).
- Increased tolerance to insect pests.
- Plant breeding programmes are carried out in a systematic way worldwide–in government institutions and commercial companies.

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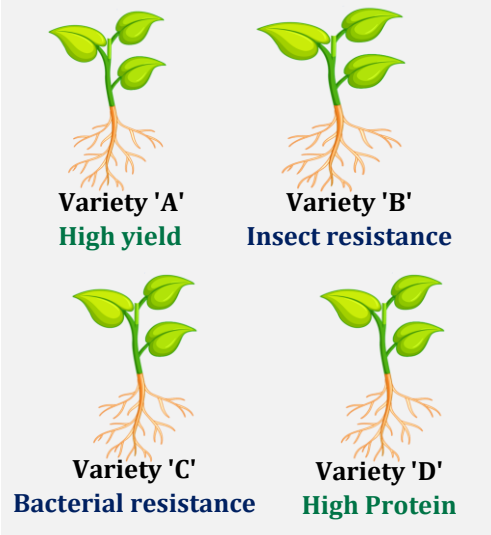
The main steps in breeding a new genetic variety of a crop by selection and hybridization are :

(A) Collection of Variability:

Genetic variability is the root of any breeding programme. In plant breeding collection of variability is done by collection of plant varieties. It consists of :

(a) Cultivated improved varieties
(b) Improved varieties that are no more cultivated
(c) Old local or desi varieties.
(d) Varieties produced by plant breeders (undistributed)
(e) Wild species related to the crop species

The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called **germplasm** collection.



Significance of germplasm of wild species :-

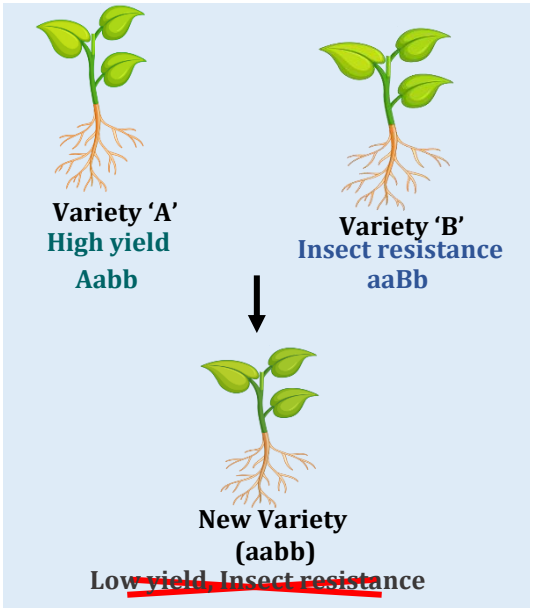
- It is very important to conserve wild species of plant as these are highly resistant to insects, pests, disease and unfavourable growth conditions, which are necessary for survival of plants.
- The loss of wild plants, will reduce the genetic variability and will be a great loss to gene pool.

(B) Evaluation and Selection of Parents :

The germplasm is evaluated so as to identify plants with desirable combination of characters. The selected plants are multiplied and used in the process of hybridisation. Purelines are created wherever desirable and possible.

(C) Cross hybridisation among the selected parents :

- The desired characters have very often to be combined from two different plants (parents), for example high protein quality of one parent may need to be combined with disease resistance from another parent.
- This is possible by cross hybridising the two parents to produce hybrids that genetically combine the desired characters in one plant.
- This is a very **time-consuming** and **tedious** process since the pollen grains from the desirable plant chosen as male parent have to be collected and placed on the stigma of the flowers selected as female parent. Also, it is not necessary that the hybrids do combine the desirable characters; usually only one in few hundred to a thousand crosses shows the desirable combination.



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(D) Selection and testing of superior recombinants :

- This step consists of selecting, among the progeny of the hybrids, those plants that have the desired character combination. **The selection process is crucial to the success of the breeding objective and requires careful scientific evaluation of the progeny.**

- This step yields plants that are superior to both of the parents (very often more than one superior progeny plant may become available). These are **self-pollinated** for several generations till they reach a state of **uniformity (homozygosity)**, so that the characters will not segregate in the progeny.

(E) Testing, release and commercialisation of new cultivars :

- The newly selected lines are evaluated for their yield and other **agronomic traits** of quality, disease resistance, etc. This evaluation is done by growing these in the research fields and recording their performance under ideal fertiliser application irrigation, and other crop management practices.
- The evaluation in research fields is followed by testing the materials in farmers fields, for at least three growing seasons at several locations in the country, representing all the agro-climatic zones where the crop is usually grown. The material is evaluated in comparison to the best available local crop cultivar -a check or reference cultivar.
- In India, **Indian Council of Agricultural Research, New Delhi (ICAR, New Delhi)** carries out the evaluations.
- Ultimately a new pure line, population or hybrid that is superior to the existing verities as well as to other new material may be released as new variety.

Mutation Breeding :

- Use of induced mutations in plant breeding to develop improved varieties. Induced mutations are useful in specific situations, when the desired alleles are absent in the germplasm.
- Many important varieties in different crop plants have been produced by mutation breeding.
- In wheat : **Sharbati sonora** and **pusa lerma** are two important varieties of wheat produced by gamma rays treatment of ***sonora-64*** and ***lerma rojo*** (Mexican dwarf wheat varieties).
- Sharbati-sonora is variety of wheat produced by **Dr. M.S. Swaminathan** and is responsible for **green revolution** in India.
- **In rice :** About 45 varieties up to 1992 have been produced by mutation breeding ***e.g.*** **Reimei & Atomita-2**
- **In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations.**
- Mutation breeding has some important limitations as :
  - **(a)** Most of the mutations are recessive.
  - **(b)** Mutation rate is extremely low.
  - **(c)** Most of the induced mutation are invaluable to the breeders and many of them are lethal.
  - **(d)** Stability of mutant is sometimes doubtful, as some mutants have tendency to revert back to original type.

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3. Applications of Plant Breeding :

(A) Plant breeding for improvement of yield :

(i) Improvement in Wheat :

- Prior to green revolution a dwarfing gene of wheat named **Norin-10**, was noted in Japan.
- Dr. N. Borlaug (Mexican wheat breeder) develop many semi dwarf wheat varieties like **Sonora-64** and **Lerma rojo-64**
- N. Borlaug got Nobel prize for peace in 1970. He is also known as **father of green revolution**.
- In 1963 two Mexican wheat varieties viz. Sonora-64 & Lerma rojo-64 and a Japanese variety Norin-10 were introduced in India, but these varieties could not adapt to Indian conditions, they were subjected to mutations and selections at Indian Agricultural Research Institute at New Delhi under the direction of Dr. M.S. Swaminathan.
- **Dr. M.S. Swaminathan :** He is pioneer in mutation breeding. He has produced Sharbati sonora variety of wheat by mutation, which is responsible for green revolution in India. He is known as **"Father of green revolution in India"**
- In 1963, several varieties such as **Sonalika** and **Kalyan Sona**, which were **high yielding** and **disease resistant**, were introduced all over the wheat-growing belt of India.
- During the period 1960 to 2000, wheat production increased from 11 million tonnes to 75 million tonnes. This was due to the development of **semi-dwarf varieties** of wheat.

(ii) Improvement in Rice :

- Dwarfing gene **"dee-geo-woo-gen"** was noticed in Taiwan.
- By using this gene, TN-1 (Taichung native-1) variety of rice was developed in Taiwan.
- This gene produced many improved varieties in rice.
- This gene was picked up by IRRI (International Rice Research Institute) Manila (Philipines) and incorporated to produce high yielding early maturing IR-8 and IR-24 varieties.
- IR-36 variety of rice is resistant to grassy stunt virus.
- IR-36 is the high yielding variety of rice and has solved major food problem in Asia.
- Later better-yielding semi-dwarf varieties **Jaya** and **Ratna** were developed in India.
- During the period 1960 to 2000, rice production went up from 35 million tonnes to 89.5 million tonnes. This was due to the development of **semi-dwarf varieties** of rice.

(iii) Improvement in Sugar cane:

- ***Saccharum barberi*** was originally grown in north India, but had poor sugar content and yield. Tropical canes grown in south India ***Saccharum officinarum*** had thicker stems and higher sugar content but did not grow well in north India.
- These two species were successfully crossed to get sugar cane varieties combining the desirable qualities of high yield, thick stems, high sugar and ability to grow in the sugar cane areas of north India.

(iv) Millets :

Hybrid **maize**, **jowar** and **bajra** have been successfully developed in India. Hybrid breeding have led to the development of several high yielding varieties resistant to water stress.

(B) Plant Breeding for Disease Resistance :

- A wide range of fungal, bacterial and viral pathogens, affect the yield of cultivated crop species, especially in tropical climates. Crop losses can often be significant, up to 20-30 per cent, or sometimes even total. In this situation, breeding and development of cultivars resistant to disease enhances food production. This also helps reduce the dependence on use of fungicides and bactericides.
- Resistance of the host plant is the ability to prevent the pathogen from causing disease and is determined by the genetic constitution of the host plant. Before breeding is undertaken, it is important to know about the causative organism and the mode of transmission.
- Some of the diseases caused by
- By **fungi** are rusts, ***e.g.***, brown rust of wheat, red rot of sugarcane and late blight of potato;
- By **bacteria**, ***e.g.***, black rot of crucifers;
- By **viruses**, ***e.g.***, tobacco mosaic, turnip mosaic, etc.

Methods of breeding for disease resistance: Breeding is carried out by the conventional breeding techniques or by mutation breeding. The conventional method of breeding for disease resistance is that of hybridisation and selection. Some crop varieties breed by hybridisation and selection, for disease resistance to fungi, bacteria and viral diseases are released.

Crop	Variety	Resistance to diseases
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	Pusa swarnim (Karan rai)	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K-1	Black rot and Curl, blight black rot
Cowpea	Pusa komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and leaf curl

- Several wild relatives of different cultivated species of plants have been shown to have certain resistant characters but have very low yield. Hence, there is a need to introduce the resistant genes into the high-yielding cultivated varieties.
- Resistance to yellow mosaic virus in ***bhindi*** (***Abelmoschus esculentus***) was transferred from a wild species and resulted in a new variety of *A. esculentus* called ***Parbhani kranti***.

(C) Plant Breeding for Developing Resistance to Insect Pests :

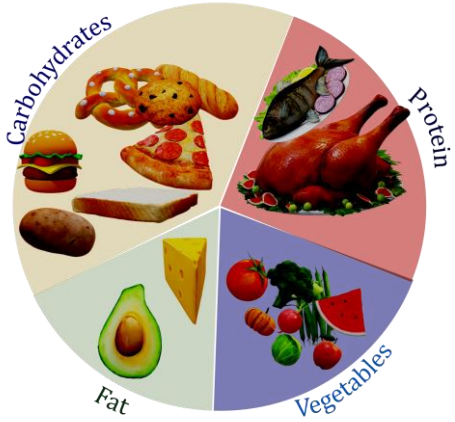
- Another major cause for large scale destruction of crop plant and crop produce is **insect** and **pest infestation**.
- Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics.

Crop	Controlled Insect	Method
Cotton	Jassids	Hairy leaves
Wheat	Cereal leaf beetle	Hairy leaves
Wheat	Stem sawfly	Solid stems
Cotton	Bollworms	Smooth leaved and nectar-less
Maize	Maize stem borers	High aspartic acid, Low nitrogen and Low sugar content

Some released crop varieties bred by hybridisation and selection, for insect pest resistance are given in Table.

Crop	Variety	Insect Pests
Brassica (rapeseed mustard)	Pusa Gaurav	Aphids
Flat bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Sawani, Pusa A-4	Shoot and fruit borer

(D) Plant Breeding for Improved Food Quality:



- More than 840 million people in the world do not have adequate food to meet their daily food and nutritional requirements.
- A far greater number three billion people suffer from micronutrient, protein and vitamin deficiencies or hidden hunger, because they **cannot afford to buy enough fruits, vegetables, legumes, fish and meat**.
- Diets lacking essential micronutrients, particularly iron, vitamin A, iodine and zinc, increase the risk for disease, reduce lifespan and reduce mental abilities.

Biofortification - breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats is the most practical means to improve public health. Breeding for improved nutritional quality is undertaken with the objectives of improving.

(a) Protein content and quality
(b) Oil content and quality
(c) Vitamin content
(d) Micronutrient and mineral content

Spirulina

- In 2000, maize hybrids that had twice the amount of the amino acids, **lysine** and **tryptophan**, compared to existing maize hybrids were developed.
- Wheat variety, **Atlas 66**, having a high protein content, has been used as a donor for improving cultivated wheat.
- It has been possible to develop an iron-fortified rice variety containing over five times as much iron as in commonly consumed varieties.
- **The Indian Agricultural Research Institute, New Delhi** has also released several vegetable crops that are rich in vitamins and minerals:-

e.g. **Vitamin A enriched** carrots, spinach, pumpkin.
Vitamin C enriched bitter gourd, bathua, mustard, tomato.
Iron and calcium enriched spinach and bathua.
Protein enriched beans broad, lablab, French and garden peas.

Limitations of conventional breeding :

- Conventional breeding is often constrained by the availability of limited number of **disease resistance genes** that are present and identified in various crop varieties or wild relatives.

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Single Cell Protein (SCP) :

- This biomass is obtained from both uni and multi cellular microorganism. Single cell protein can be produced using **algae**, **fungi**, **yeast** and **bacteria**.
- Conventional agricultural production of cereals, pulses, vegetables, fruits, etc., may not be able to meet the demand of food at the rate at which human and animal population is increasing.
- The shift from grain to meat diets also creates more demand for cereals as it takes 3-10 Kg of grain to produce 1 Kg of meat by animal farming. More than 25 per cent of human population is suffering from hunger and malnutrition. One of the alternate sources of proteins for animal and human nutrition is **Single Cell Protein (SCP).**
- Microbes like ***Spirulina*** can be grown easily on materials like waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage, to produce large quantities and can serve as food rich in protein, minerals, fats, carbohydrate and vitamins. Incidentally such utilisation also reduces environmental pollution.
- It has been calculated that a 250Kg cow produces 200g of protein per day. In the same period, 250g of a micro-organism like *Methylophilus methylotrophus*, because of its high rate of biomass production and growth, can be expected to produce 25 tonnes of protein. The fact that mushrooms are eaten by many people and large-scale mushroom culture is a growing industry makes it believable that microbes too would become acceptable as food.

4. Plant Tissue Culture:

- Tissue culture technique is based on **totipotent nature** of plant cell.

  Totipotency : The ability of a plant cell to regenerate into a complete plantlet.
- Plant tissue culture is the technique of maintaining and growing plant cells, tissues and organs in sterilized culture medium, under controlled aseptic conditions (in-vitro).
- This is one of the latest and most promising methods of crop improvement in such plant, where all other conventional methods of breeding fail.

Explant :-

Plant part that is excised from its original location and used for initiating a culture. It may be root tip, shoot bud, anther, embryo, ovule etc. Normally undifferentiated cells (meristematic cells) of plant are used as explant.

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Surface Sterilization :-

- The process of treatment of explant with specific antimicrobial chemicals like sodium hypochlorite, H_2O_2, Bromine water, C_2H_5OH etc.
- The vessels, media and instruments are also sterilized by treating them with steam, dry heat or alcohol.

Culture medium :-

- Medium, which is provides nutrition to explants and required for normal growth and development of explants.
- Standard culture medium (Nutrient medium) contains Inorganic salts, Vitamins, Sucrose (as a source of energy and carbon), Amino acid, Growth regulators (2,4–D, Cytokinins, BAP–benzylaminopurine).
- Growth regulators are required for **cell division** and **organogenesis** in explant.
- **Murashige and Skoog's (MS)** culture medium (Most commonly used culture medium).

Callus :-

- By culturing explant in culture medium an **undifferentiated mass** of cells is obtained which is known as **callus**.

Types of cultures :

- Callus culture & Suspension culture.
- Meristem culture
- Embryo culture
- Anther culture
- Protoplast culture

(A) Callus Culture & Suspension Culture :

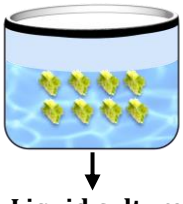
(i) Callus culture: -

In callus culture an explant is placed on a solid medium containing agar. many of the cells become meristematic and begin to divide and giving rise to callus in 2–3 weeks.

The agar medium contains both type of growth regulators **auxin** like **2,4-D** and **cytokinin** like **BAP**.

(ii) Suspension culture: -

- In case of suspension culture, a single cell or small group of cells is placed on liquid medium. The medium normally contains the **auxin 2,4-D**. These cells divide and form small groups of cells.
- The suspension cultures are continuously **agitated** to break the cell mass into smaller clumps and single cells and also maintain uniform distribution of cells and cell clumps in the medium. It also allows gaseous exchange.
- Suspension cultures grow much faster than callus culture.
- Suspension cultures can be maintained in either of the following two forms.
- **Batch cultures:-** are initiated as single cells in a flask and are propagated by transferring regularly small groups of suspensions to a fresh medium.
- **Continuous cultures:-** are maintained in a steady state for long period by draining out the used medium and adding from new medium.



Liquid culture medium

Formation of plantlets: -

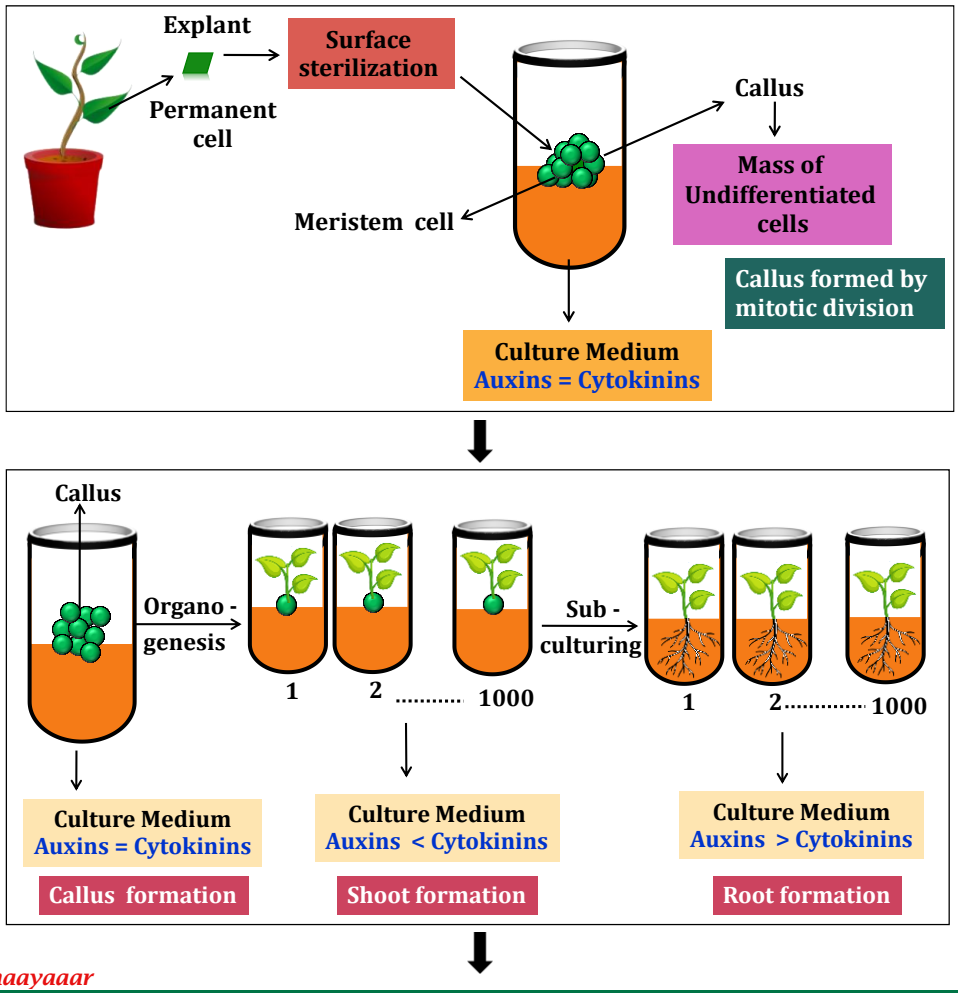
- **Haberlandt** was first one who grew isolated leaf cells by plant tissue culture.
- Totipotency: - The ability of a plant cell to regenerate into a complete plantlet.
- **Regeneration** can be described as the development of specific structure like root, shoot or somatic embryo from cultured cells.

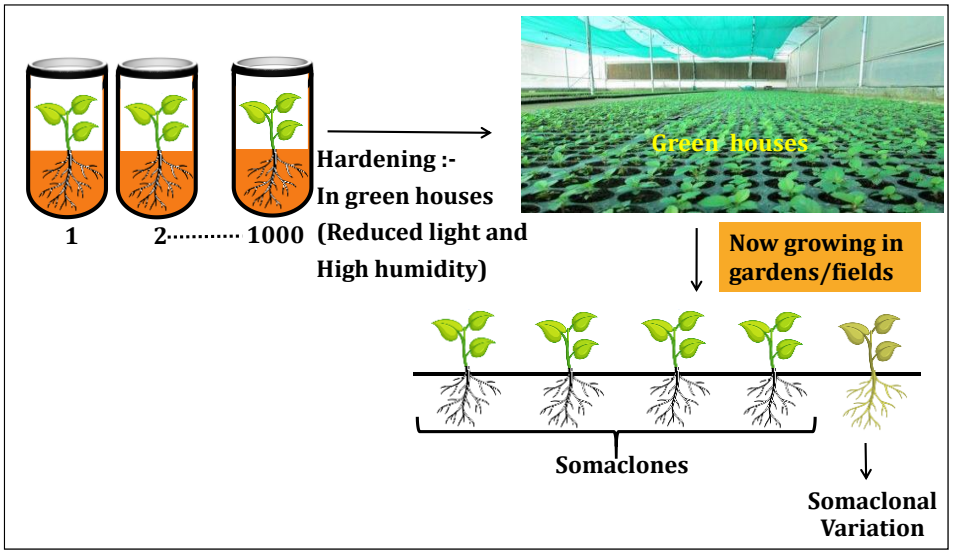
Shoot and root formation: -

- The two important components of a plant are root and shoot.
- The regeneration of root and shoot is controlled by two types of growth regulators.
- The auxin like **NAA** (Naphthaline Acetic Acid) promotes root regeneration, whereas **cytokinins** like **BAP** promotes shoot regeneration.
- Callus cultures first kept on medium containing BAP, which initiates shoot formation from the callus.
- When shoots become 2-3 cm. long, the culture is transferred to a medium containing auxin. Roots develop from the lower ends of these shoots and develop into young plant called **plantlet**.

Somatic embryo regeneration :-

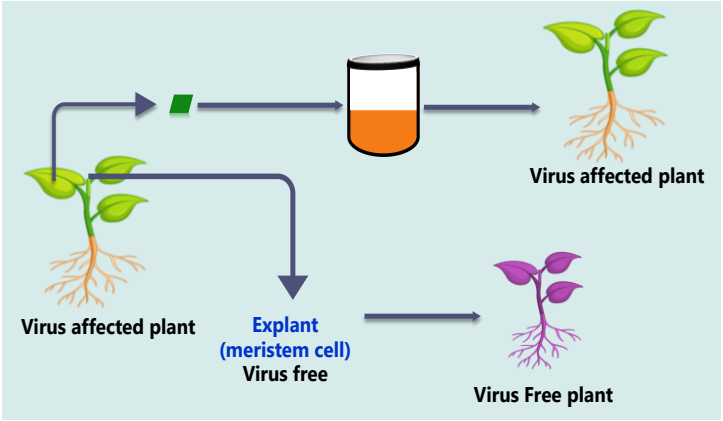
- Somatic embryo or embryoids are non-zygotic embryo like structures that develop in vitro cultures from somatic cells.
- The medium having **ammonium nitrate** and **auxin (2,4-D)** favour induces their differentiation.
- Mature somatic embryos germinate to yield complete plantlets.





(B) Meristem Culture :

- Use of an explant that contains pre-existing shoot meristems and produce shoot from them.
- Both apical and axillary meristem can be used as explant.
- Explant (shoot tips or nodal segments) are cultured on a medium containing cytokinin (usually BAP).
- Cytokinin promotes axillary branching by overcoming apical dominance.
- When the plantlet has grown a few leaves, it is transferred to soil after hardening.



Meristem culture can be used for :-

- Rapid clonal multiplication.
- Production of virus free plants.
- Conservation of germplasm.
- Production of transgenic plants.

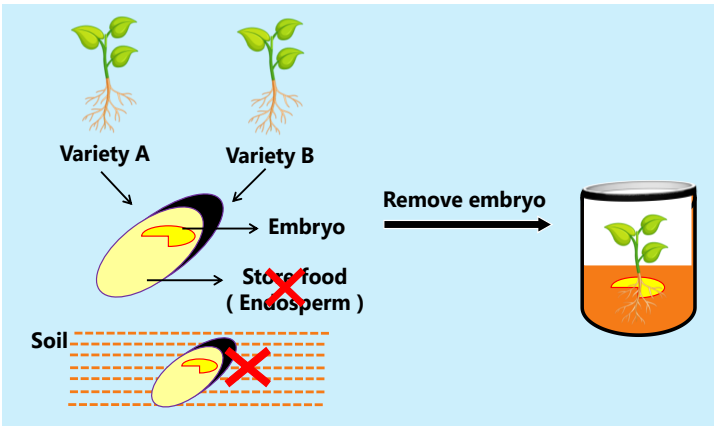
Scientists have succeeded in culturing meristems of banana, sugarcane, potato, etc.

(C) Embryo Culture :

Excision of young embryos from developing seeds and their cultivation on a nutrient medium is called **embryo culture**.

Application of embryo culture method to prevent the abortion of the interspecific hybrid embryo is called **embryo rescue**.

Aim : Allow young embryos to develop into complete seedlings & overcoming hybridization barriers.



Applications of embryo culture :-

- In some interspecific crosses, the endosperm of developing hybrid seeds degenerate very early, so young hybrid embryo which gets devoid of nutrition also dies in such cases, the young hybrid embryo is excised and cultured in vitro to obtain hybrid seedling.
- Seeds of some plants like **orchid** lack stored food. In such cases embryo culture allows seedling development from the embryos. This method is also used for **rapid clonal propagation** in orchid.
- In some species, seeds may remains **dormant** due to **inhibitors** present in the endosperms/seed coat. Embryo culture in such cases allows embryo development by eliminating the inhibitors responsible for dormancy.

(D) Anther Culture & Haploid Production :

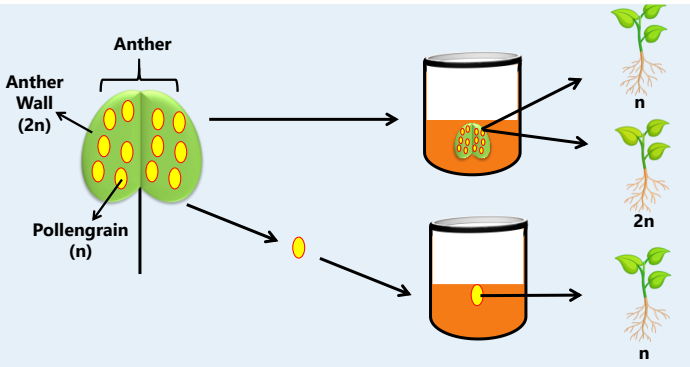
- Anther culture is also known as pollen grain culture or androgenic haploid culture.
- When anthers of a plant species are cultured on a suitable medium, then haploid plants are produced, this method is called **anther culture**.
- This technique was first used in India to produce haploid plants of ***Datura innoxia*** by **Guha** and **Maheshwari (1964)**.
- Sometime diploid plants are also formed among haploid plants. Source of these diploid plants is anther wall (which is diploid).
- Haploid can also be produced by culturing unfertilised ovules.

Haploid plants are very useful in plant breeding because: -

(i) They have single set of chromosome, so even a very small change or mutation can be detected in haploids.

(ii) These haploids are used to produce homozygous diploids (by colchicine treatment) and these homozygous diploids are used as parents in crossing.

(iii) Use of haploids in producing pure lines has reduced the period required for developing new varieties from 10 years to 5 years.



(E) Protoplast Culture :

Protoplast : Cell wall less plant cell is called protoplast.

Somatic hybrid : A hybrid produced by fusion of somatic cells of two species or varieties. The process of production of somatic hybrid is somatic hybridisation.

Steps of somatic hybridisation :-

(i) **Removal of cell wall** : In this step, cell wall is digested by using pectinase & cellulase enzyme.

(ii) **Fusion between protoplast :-**

- Protoplast of two different species are fused together.
- Substance which induces the fusion of protoplast are called fusogen or fusogenic agent.
- **Fusogenic substance and condition :–**

By treatment of $NaNO_3$

By treatment of Ca^{2+} ions at high pH

By treatment of polyethylene glycol [PEG]

By high voltage electric shock

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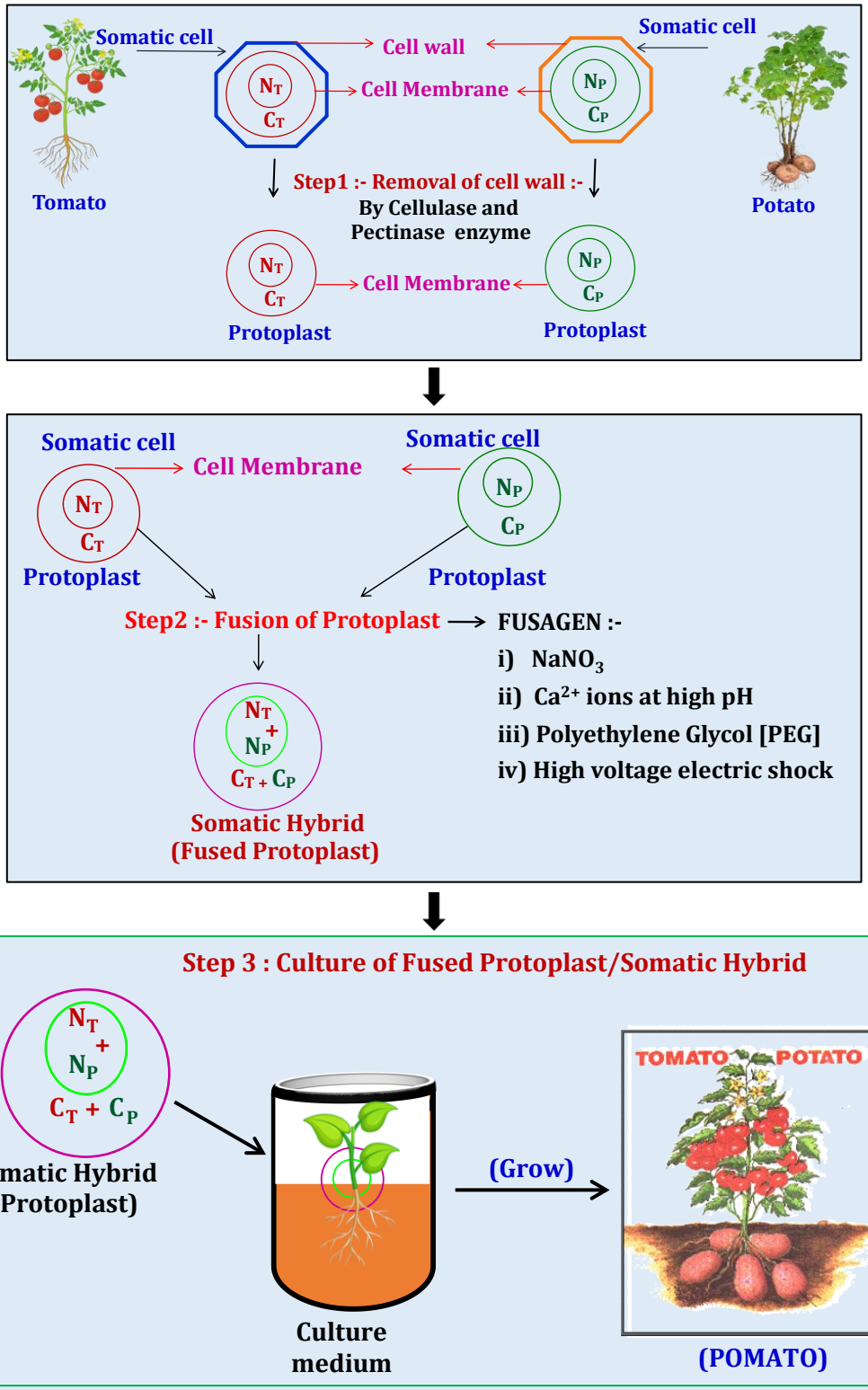
(iii) Culture of the fused protoplast :-

Product of fused protoplast of two different species is called **heterokaryon**.

Heterokaryons are mainly used in tissue culture.

When the fused protoplasts are cultured on a suitable medium they regenerate cell wall and begin to divide to ultimately produce plantlets.



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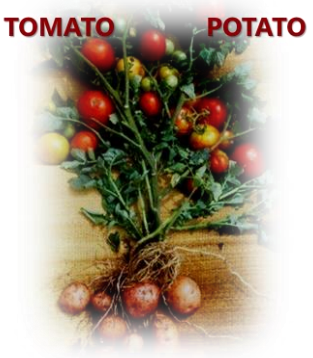
Importance of somatic hybridisation :–

- Production of hybrids between different lines and species that can not be produced normally by sexual reproduction. ***e.g.*** Rice & Carrot
- **Pomato** is a somatic hybrid between potato and tomato.
- **Bromato** is a somatic hybrid between Brinjal & tomato.
- Somatic hybridisation is also called **parasexual hybridisation**. First somatic hybrids were obtained between two species of tobacco ***Nicotiana glauca*** and ***N. Langsdorfii*** by **Carlson** et. al.



(POMATO)

5. Cybrid/Cytoplasmic Hybrid:

Cybrids possess a nuclear genome from only one parent but cytoplasmic genes from both parents. The process of protoplast fusion resulting in the development of cybrid is known as cybridisation.

6. Application of Plant Tissue Culture:

(i) Rapid clonal prorogation of superior lines:

- **Clone :** Group of individuals or cells derived from a single individual or cell by asexual reproduction.
- Multiplication of genetically identical copies of a cultivar by asexual reproduction is called **clonal propagation or cloning or micro propagation.**
- All the cells in culture are derived from a single explant by mitotic division, so all plantlets regenerate from a culture generally, have the same genotype and constitute a clone.
- Two common types of micro propagation are: -
  (a) Multiple shootlet production
  (b) Somatic embryogenesis

(ii) Somaclonal variation :-

- Genetic variation presents among plants regenerated from tissue culture have been termed as **somaclonal variation.**
- **Somaclones** are those plant which are genetically identical to the original plant from which they were grown.
- These variations originated by minor chromosomal aberration, by gene mutation etc.
- The variation which are stable and have agronomic characters like resistance to diseases and pests, tolerance to stress, early maturation, better yields are useful only.

(iii) To produce transgenic plants.

TG: @Chalnaayaaar

BEGINNER'S BOX-1

STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

1. Who developed Dwarf wheat, first of all?
(1) M.S. Swaminathan (2) Vavilov
(3) Borlaug (4) B.D. Singh

2. Breeding of crops with high levels of minerals, vitamins and proteins is called :-
(1) Biomagnification (2) Micropropagation
(3) Somatic hybridisation (4) Biofortification

3. Select the correctly match pair:-
(1) Nectar-less cotton varieties do not attract bollworms
(2) All microbes can be used as Single cell protein
(3) High aspartic acid content in wheat do not attract jassids
(4) Wheat variety, Pusa Gaurav has been used as a donor for improving cultivated wheat.

4. The pair of hormones required for a callus to differentiate are_____.
(1) Ethylene and auxin (2) Auxin and cytokinin
(3) Auxin and abscisic acid (4) Cytokinin and gibberellin

5. What is Callus?
(1) Tissues that grow to explant
(2) An unorganised actively dividing the mass of cells maintained in a culture
(3) An insoluble carbohydrate
(4) A tissue that grows from an embryo

6. Haploids are more suitable for mutation studies than the diploids. This is because:-
(1) Haploids are more abundant in nature than diploids
(2) All mutations, whether dominant or recessive are expressed in haploids
(3) Haploids are reproductively more stable than diploids
(4) Mutagens penetrate in haploids more effectively than in diploids.

7. Somaclonal variations appear in:-
(1) Organism produced through somatic hybridization
(2) Plants growing in highly polluted conditions
(3) Apomictic plants
(4) Tissue culture raised plants

8. Which of the following is the main application of embryo culture?
(1) Clonal propagation (2) Production of embryoids
(3) Induction of somaclonal variations (4) Overcoming hybridisation barriers

BEGINNER'S BOX ANSWERS KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	
	Ans.	3	4	1	2	2	2	4	4	

Strategies for Enhancement in Food Production

Plant Breeding

Steps :
1. Collection of variability
2. Evaluation and selection of parents
3. Cross hybridisation among selected parents
4. Selection and testing of superior recombinants
5. Testing, release and commercialisation of new cultivars

High yielding variety :
1. Wheat – Sonalika and Kalyan sona
2. Rice – Jaya and Ratna
3. Sugarcane – *Saccharum officinarum*

Disease resistance :
1. Wheat – Himgiri
2. Brassica – Pusa swarnim
3. Cauli flower – Pusa subhra, Pusa snowball k-1
4. Cow pea – Pusa komal
5. Chilli – Pusa sadabahar

Resistance to insects pests :
1. Brassica – Pusa Gaurav
2. Flat bean – Pusa Sem 2, Pusa Sem 3
3. Okra – Pusa sawani, Pusa A-4

Biofortification :
1. Protein content and quality
2. Oil content and quality
3. Vitamin content
4. Micronutrient and mineral content

Single Cell Protein (SCP)
- BGA – *Spirullina*
- Bacteria – *Methylophilus methylotrophus*

Tissue Culture

Totipotency : Whole plant – Any cell/explant

Requirement :
- Explant
- Nutrient medium – carbon and energy source - sucrose
- Inorganic salts
- Vitamins
- Amino acids
- PGRs – Auxin, Cytokinin

Micropropagation :
Thousand of genetically identical plants, each plant – Somaclone
e.g. Tomato, Banana, Apple

Meristem culture (apical & axillary meristem) :
Virus free plant
e.g. Banana, Sugarcane, Potato

Somatic Hybridisation :
- Fusion of isolated protoplast
- Tomato and potato – Pomato